Materials Engineering Branch

TIP*

No. 114 Controlling Outgassing from Organic Materials

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It has always been the policy of GSFC and other NASA centers to select the lowest outgassing materials available for use on spacecraft and flight instruments. Johnson Space Center Specification SP-R-0022A established the requirement that flight materials, when tested in accordance with ASTM E-595, should have a total mass loss (TML) of less than 1% and a collected volatile condensable material (CVCM) of less than 0.1%.

Some materials that do not meet the above requirements have been used when lower outgassing alternatives were not available. In those cases, extended cure cycles, vacuum bake outs and other techniques have been used to reduce outgassing as much as possible.

Over coating was one method frequently used to reduce outgassing from materials such as marking inks. In this process, a high outgassing material would be over-coated with a low outgassing material with the belief that the low outgassing material would seal the high outgassing material thus preventing it from outgassing.

The Materials Engineering Branch conducted a series of tests to determine if over coating did, in fact, reduce the outgassing of coated materials. In these tests, a high outgassing black marking ink was over coated with four low outgassing clear coatings commonly recommended for this purpose. They were: a polyurethane conformal coating, a silicone conformal coating, an epoxy, and a polyester/acrylic tape. Test results indicated that none of these materials prevented the over coated material from outgassing.

Over coating did, however, impede the rate at which the ink outgassed. The outgassing of the ink, in the overcoat configuration, is primarily governed by the thickness of the overcoat and the diffusion of the ink's volatiles through the film.

An extreme example of over coating is the "sandwiching" of a high outgassing material between two impermeable layers, such as metallic plate. The diffusion path is now via the edges of the outgassing material. Thus, even though the rate of outgassing will be impeded considerably, the same total outgassing will occur.

These results emphasize the importance of selecting the lowest outgassing materials available and not relying on secondary processes unless they have been proven effective experimentally. The following guidelines have been developed for instrumenters who must use marking inks on their payloads

- Use as little ink as possible. Engraving, etching, or removable labels[1] should be used in lieu of ink where possible. Only apply essential information directly to flight hardware. Other information can be provided on records that accompany the hardware.

- Use the lowest outgassing materials available. The Materials Engineering Branch has tested room temperature curing marking inks with TML's between 6 and 16%.

- Use a high temperature cure if possible (e.g., one ink that we tested had a TML of 8% when cured at room temperature. The same ink had a TML of 3.5% when cured at 88°C for 2 hours). Most inks will pass the outgassing requirements after a bake out of approximately 125° C to 150° C.

- Do not rely on over coating to prevent outgassing from a material. Although some materials may be more effective as overcoats than others, tests performed in our laboratories show that many over coating materials generally believed to be effective, are not.

Precautionary Note: The time to reach mechanical equilibrium (dimensional stability, etc.), in space is dependent on the rate of outgassing of volatile species. Therefore, it may be disadvantageous to impede these mechanisms by such means as over coating.

[1] If removable labels are used, be certain to clean all residual adhesive from the hardware following label removal.